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October 25, 2000

Magalie Roman Salas, Secretary
Federal Communications Commission
Counter TW-A325
The Portals, 445 12th Street, S.W.
Washington, D.C. 20554

Re: Ex Parte Submission of Northpoint Technology, Ltd.
ET Docket No. 98-206, RM-9147, RM-9245

Dear Ms. Salas:

Northpoint Technology, Ltd. ("Northpoint") would like to correct a few specific errors that have been made in connection with the above-cited proceedings by providers of direct broadcast satellite service ("DBS"), EchoStar and DirecTV. These errors can be found in a letter filed by the DBS operators on October 11, 2000[1] and they were repeated in a debate among certain parties to these proceedings before Commissioner Ness and members of the Commission's staff on October 19, 2000.

EchoStar and DirecTV erroneously suggest that "an international and U.S. standard already exists for assessing harmful interference into DBS receivers"[2] from the Northpoint system and that this international standard is determinative of the issues surrounding Northpoint/DBS sharing. While it is true that an international standard to assess NGSO FSS/DBS interference issues does exist, EchoStar and

[1] Letter to Donald Abelson, Chief, FCC International Bureau, and Dale Hatfield, Chief, FCC Office of Engineering and Technology, from Counsel for EchoStar Satellite Corp. and DirecTV, Inc., dated October 11, 2000 ("October 11 Letter").

[2] October 11 Letter at page 2.

DirecTV are simply incorrect in asserting that this criterion applies to Northpoint/DBS sharing.

Specifically, EchoStar and DirecTV cite certain ITU and CPM documents for the proposition that interference into DBS must be limited such that "the aggregate interference – from all sources – should not be responsible for more than a 10% increase in link unavailability."[3] The documents that EchoStar and DirecTV cite for this proposition (namely, Recommendation ITU-R BO.1444 and CPM Chapter 3) do not support this conclusion. As the attached copy of Recommendation ITU-R BO.1444 clearly states, the recommendation was adopted to "define criteria to protect a network in the BSS and associated feeder links from interference caused by non-GSO FSS systems."[4] Likewise, as the attached copy of Chapter 3 of the CPM shows, the 10% figure for the increase in the unavailability of DBS links is used to determine only "the impact on [DBS] from non-GSO FSS systems."[5] In other words, the ITU recommendation and CPM text cited by EchoStar and DirecTV simply do not address interference from sources other than NGSO FSS systems. Accordingly, the Commission should not permit EchoStar and DirecTV to mislead it into thinking that these documents somehow determine the issues surrounding Northpoint/DBS sharing.

The international table of allocations provides guidance on Northpoint/DBS sharing issues because it clearly designates fixed services (FS) as

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3 *Id.* at page 5.

4 Recommendation ITU-R BO.1444, considering clause (n) (emphasis added). Moreover, section 1.1 of this recommendation states that all NGSO FSS satellite systems in the 12.2-12.7 GHz band should be responsible for at most 10% of the time allowance for unavailability of the given C/N value, where N is the total noise level in the noise bandwidth associated with the wanted carrier including all other non-time-varying sources of interference. In other words, given that N already includes interference from FS (a non-time-varying source of interference), a Northpoint system would be separately accounted for in the sharing environment analyzed by this recommendation and the 10% increase in unavailability very clearly is directed at NGSO FSS systems only.

5 CPM, Chapter 3, para. 3.1.3.1.3 (emphasis added).

primary in the 12.2-12.7 GHz band on a world wide basis.[6] Thus, the attempts by EchoStar and DirecTV to exclude Northpoint from the band are misplaced. Moreover, the international table of allocations already requires Northpoint and other FS services not to cause harmful interference to DBS,[7] and, accordingly, the interests of DBS consumers are already adequately protected.

Finally, even if the Commission were to determine that international agreements specified a definitive interference criterion for Northpoint/DBS sharing – which the Commission should not – the Commission can and should take exception to those international agreements for a purely domestic service such as Northpoint's which would serve the public interest so well.

An original and six copies of this letter are submitted for inclusion in the public record for the above-captioned proceedings. Please direct any questions concerning this submission to the undersigned.

Sincerely,

David H. Pawlik
Counsel to Northpoint Technology, Ltd.

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6 47 C.F.R. § 2.106

7 *See* Amendment of Part 2 of the Commission's Rules to Make Non-Substantive Revisions to the Table of Frequency Allocations, 15 FCC Rcd 3459, 1999 FCC LEXIS 6428, Appendix A, International Footnotes in the United States Table, 15 FCC Rcd at 3479 ("S5.490 In Region 2, in the band 12.2-12.7 GHz, existing and future terrestrial radiocommunication services shall not cause harmful interference to the space services operating in conformity with the broadcasting-satellite Plan for Region 2 contained in Appendix S30.").

cc: Commissioner Susan Ness
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Commissioner Michael Powell
Commissioner Gloria Tristani
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RECOMMENDATION ITU-R BO.1444

PROTECTION OF THE BSS IN THE 12 GHz BAND AND ASSOCIATED FEEDER LINKS IN THE 17 GHz BAND FROM INTERFERENCE CAUSED BY NON-GSO FSS SYSTEMS

(Questions ITU-R 85/11 and ITU-R 223/11)

(2000)

The ITU Radiocommunication Assembly,

considering

a) that the bands 11.7-12.5 GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz in Region 3 are allocated to the BSS;

b) that the BSS in the above bands is subject to the Plans in RR Appendix S30;

c) that the bands 17.3-17.8 GHz in Region 2 and 17.3-18.1 GHz in Regions 1 and 3 are allocated to the feeder links of the BSS;

d) that the feeder links of the BSS in the above bands are subject to the Plans in RR Appendix S30A;

e) that the band 12.5-12.75 GHz in Region 3 is also allocated to the BSS;

f) that the band 17.8-18.1 GHz in Region 2 is also allocated to the feeder links of the BSS;

g) that WRC-97 allocated the bands 11.7-12.5 GHz in Region 1, 12.2-12.7 GHz in Region 2, 11.7-12.2 GHz and 12.5-12.75 GHz in Region 3 to the non-GSO FSS (space-to-Earth) and 17.3-17.8 GHz in Regions 1 and 3 and 17.8-18.1 GHz in Regions 1, 2 and 3 to the non-GSO FSS (Earth-to-space) subject to the provisions of Resolution 538 (WRC-97);

h) that emissions from the stations of non-GSO satellite systems may result in interference to BSS networks and associated feeder links when these networks operate in the same frequency bands;

j) that RR No. S22.2 states that non-GSO satellite systems shall not cause unacceptable interference to GSO satellite systems in the FSS and BSS operating in accordance with the RR;

k) that WRC-97 adopted provisional equivalent power flux-density (epfd) limits to quantify the level of unacceptable non-GSO interference and requested ITU-R to review these limits in order to ensure appropriate protection of the Plans and their future modifications;

l) that there exist criteria to protect the BSS networks and associated feeder links from other such networks operating in the same regional plan or in another Regional Plan (RR Appendix S30, Annex 1 and RR Appendix S30A, Annex 1);

m) that there exist criteria to protect the BSS networks from FSS networks in another Region (RR Appendix S30, Annex 4) and to protect the associated feeder links from FSS networks in the same or in another Region (RR Appendix S30A, Annex 4);

n) that there is a need to define criteria to protect a network in the BSS and associated feeder links from interference caused by non-GSO FSS systems;

o) that the harmonious development of non-GSO FSS systems and GSO BSS and associated feeder-link networks requires that the conditions under which the sharing would be feasible should be identified as soon as possible;

p) that the integrity of the Plans in RR Appendices S30 and S30A and their future modifications is to be ensured, *considering further*

a) that the BSS and associated feeder-link system designer should be able to control the overall performance of a network and to provide a quality of service that meets its *C/N* performance objectives;

b) that to allow an operator to exercise control over the quality of service, there needs to be a limit on the aggregate interference a network must be able to tolerate from emissions of all other networks;

c) that in order to facilitate the introduction of non-GSO FSS systems in accordance with the provisions of RR Article S22, it is necessary to establish sharing criteria that are applicable to individual non-GSO FSS systems;

d) that in frequency bands above 10 GHz where very high propagation attenuation may occur for short periods of time, it may be desirable for GSO and non-GSO systems to make use of some form of fade compensation;

e) that in interference situations involving non-GSO systems, BSS and associated feeder-link networks are potentially exposed to high levels of interference for short periods of time which could affect the performance or availability of these networks;

f) that short-term interference events may cause a loss of video picture continuity or other unstable conditions in digital BSS transmissions which may cause a degradation or loss of service for periods longer than interference events;

g) that in interference situations involving non-GSO systems, BSS networks and associated feeder links are potentially exposed to low levels of interference for long periods of time which could degrade the performance or availability of those networks;

h) that the performance and availability of an operating GSO-BSS system and its associated feeder links are degraded by external interfering noise contributions which may be steady state or of a statistical nature;

j) that such degradations may be due to propagation anomalies, other GSO networks and other systems including non-GSO FSS systems that share the same band;

k) that emissions from the earth stations as well as from the space station of a satellite network (GSO BSS and associated feeder links or non-GSO FSS) in those bands may result in interference to another such network when both networks operate in the same bands;

l) that a methodology is required to allow an accurate assessment of the time varying impact of epfd and apfd limits for non-GSO FSS networks on the performance of GSO BSS networks and associated feeder links;

m) that the methodology would facilitate the determination of appropriate epfd and apfd limits that would provide suitable protection of the GSO BSS and associated feeder links,

recommends

1 that for a GSO BSS network in the 12 GHz band and its associated feeder links in the 17 GHz band, the aggregate inter-network interference caused by the earth and space station emissions of all non-GSO FSS satellite networks operating in the same frequency band, should:

1.1 be responsible for at most 10% of the time allowance(s) for unavailability of the given *C/N* value(s) as specified in the performance objectives of the desired network, where *N* is the total noise level in the noise bandwidth associated with the wanted carrier including all other non-time-varying sources of interference;

1.2 not lead to a loss of video picture continuity (see Note 1) in the desired digital GSO BSS and associated feeder-link network under clear-sky conditions (see Note 2);

2 that epfd limits as defined in RR Article S22 and applicable respectively to non-GSO FSS systems to be operated in the 12 GHz bands shared with BSS and in the 17 GHz frequency bands shared with BSS feeder links be derived and specified in such a way:

2.1 that they satisfy the criteria in *recommends* 1.1 and 1.2 when applied to a set of representative GSO BSS and associated feeder-link system characteristics, as provided in Annex 1;

2.2 that the apportionment of the aggregate interference allowance specified in *recommends* 1.1 and 1.2 to derive single entry limits be based on the effective number of non-GSO FSS systems that are anticipated to share the same frequency bands;

2.3 that these limits are specified by continuous curves of cumulative density function for a range of representative GSO receiving antenna sizes (see Note 3);

3 that the methodologies given in Annexes 2 and 3, in connection with an appropriate assumed number of non-GSO FSS systems, be applied for assessing the impact on the GSO BSS in the 12 GHz band and the associated feeder links in the 17 GHz band of epfd and apfd limits applicable to the non-GSO FSS (see Note 4);

4 that the methodology described in Annex 4 be used to assess if the provisions of *recommends* 1.2 are satisfied;

5 that the following Notes form part of the Recommendation.

NOTE 1 – A loss of MPEG video picture continuity occurs when the BER of the demodulated MPEG video bit stream is sufficiently high to cause the associated video MPEG decoder to cease to provide one or more pictures. This condition typically results in the initiation of error concealment techniques by the video decoder, such as the presentation of the last available MPEG picture (freeze frame), presentation of an all black picture, or other techniques.

NOTE 2 – Administrations were requested to indicate the difference (dB) between the $C/(N + I)$ required at operating threshold, which is found on line 13 of the database spreadsheet, and the loss of video picture continuity performance point for each link. If this information is not provided by the responsible administration, a default value of 1.5 dB will be assumed.

NOTE 3 – Further study is required to ensure that, to the extent possible, these limits are consistent with the protection levels currently afforded to the Plans in RR Appendices S30 and S30A and their future modifications.

NOTE 4 – Calculations were carried out to establish the consistency of the results between the two methodologies. It was found that the two methods gave consistent results.

However, it was found that in some cases there are significant differences in the unavailability calculated by the two programs. Detailed studies that were performed demonstrated that differences between the two programs were encountered when analysing links using large earth stations antenna sizes (i.e. 120 cm and larger). The reason for this difference may be related to the link degradation resulting from the epfd limit for 100% of the time being close to the available degradation in the link. Administrations using these software packages should pay special attention to this finding.

ANNEX 1

BSS system characteristics

The database which is contained in this annex consists of characteristics of operational and planned GSO BSS networks and the associated feeder links provided in response to Circular Letters CR-92 and CR-116 for the purpose of arriving at recommended epfd masks which will help in sharing studies between GSO BSS and non-GSO FSS systems.

This database in Excel format is available in electronic form at the ITU Website:
http://www.itu.int//itudoc/itu-r/sg11/docs/sg11/1998-00/contrib/138e2.html

ANNEX 2

Methodology for analysing candidate $epfd_{up}$ and $epfd_{down}$ limits for the BSS and associated feeder-link bands

1 Overall principle

The operation of the GSO carrier is defined by an operational threshold in terms of a given *C/N*. This operating threshold defines the *C/N* required for this link. Time-varying phenomena within the link can cause the *C/N* to fall below the operating threshold during a certain percentage of the time. This variation can be introduced by rain but also by non-GSO FSS systems. The present methodology aims at calculating the additional percentage of the outage time where the *C/N* falls under the operating threshold due to the interference from non-GSO FSS systems.

For this purpose, the application of *recommends* 1.1 calls for the calculation of the relative increase in unavailability due to non-GSO FSS systems. This concept requires the calculation of both the unavailability without non-GSOs and the unavailability with non-GSOs in order to achieve their comparison. These two unavailabilities have to be calculated following exactly the same process in order for the comparison to be meaningful.

2 Need for a statistical approach

Degradations in the link due to rain and non-GSO interference are random events in time which can be modelled using a probability density function (pdf) (the pdf for rain, i.e. the probability that rain fade equals a given value, can be derived from Recommendation ITU-R P.618). If these phenomena are not modelled using their time-varying nature, but instead by setting them as constants equal to the worst-case value, the result would overestimate the degradation on the link.

It is therefore necessary to statistically combine time-varying degradations that can lead the *C/N* below the operating threshold, i.e.:

- rain attenuation on the uplink and on the downlink (their statistical description is included in Recommendation ITU-R P.618);
- interference from non-GSO FSS system(s) (their statistical description is reflected in the $epfd_{down}$ mask).

Each degradation source is assumed to be statistically independent from the other. This means that the occurrence of one phenomena at a given amount has no correlation with the other occurrence of the other at the same time.

3 Detailed principle

Step 1: Generate all possible combinations of each single degradation source and calculate the associated probability of occurrence, e.g. one combination will include:

- uplink rain fade = 1 dB (single probability of occurrence = 0.25% of the time);
- downlink rain fade = 0.5 dB (single probability of occurrence = 0.15% of the time);
- $epfd_{down} = -175$ dB(W/(m^2 · 4 kHz)) (single probability of occurrence = 1% of the time);
- combined probability of occurrence = 0.25% × 0.15% × 1%.

Step 2: For each of the above possible combinations, calculate the *C/N* by means of the link budgets in Annex 1 with the sources of degradation included.

Step 3: Compare the *C/N* calculated with the operating threshold in order to determine if the link is available or not.

Step 4: Sum up all the combined probabilities of occurrence corresponding to each combination in Step 1 that do not lead C/N under operating threshold. The sum represents the probability that the link is available when both non-GSO interference and rain are considered.

Step 5: Redo the process without using epfd_{down} so as to calculate the GSO link availability without non-GSO interference.

ANNEX 3

Monte Carlo implementation of evaluation methodology

1 Introduction and summary

Rain effects increase system unavailability as compared with clear-sky operations, by adding receiver system noise temperature. The presence of non-GSO system interference further increases system noise temperature and therefore system unavailability. These and many other factors must be considered in evaluating numerical system availability in the presence of non-GSO.

This Annex provides details of the Monte Carlo methodology proposed to evaluate the increase in BSS unavailability caused by non-GSO interference. First, a complete but also complex equation for unavailability is derived. The equation is then simplified with approximations. A procedure for evaluating one of the simplified equations with Monte Carlo simulation is presented. An example result of using the simulation is discussed. Finally, derivation of the slope of the Transition Regime (B) for the proposed epfd masks is provided. The non-GSO interference is not faded by rain in this analysis. Appendix 1 to this Annex provides the derivation of the degradation equations with the non-GSO interference faded by rain.

2 Proposed evaluation methodology

2.1 Derivation of degradation equations with non-GSO interference not faded by rain

In this Annex, noise, N, in a carrier-to-noise ratio, C/N, refers to the sum of all unwanted powers for a particular situation, such as thermal noise, noise temperature increase from rain, GSO interference, and/or non-GSO interference.

The total C/N is affected by uplink and downlink as:

$$C/N = \frac{(C/N)_U \cdot (C/N)_D}{(C/N)_U + (C/N)_D} = \frac{(C/N)_D}{1 + \dfrac{(C/N)_D}{(C/N)_U}} \qquad (1)$$

in which $(C/N)_U$ and $(C/N)_D$ are the uplink C/N and the downlink C/N, respectively. In turn, $(C/N)_U$ is expressed as:

$$\begin{aligned}(C/N)_U &= (C/N)_{UC}\, DG_U \\ &= \frac{(C/N)_{UC}\, \alpha_U}{1 + \dfrac{T_{\alpha_U}}{T_U} + \dfrac{I_{UG} + I_{UN}}{N_U}} \\ &= \frac{(C/N)_{UC}}{\dfrac{1}{\alpha_U}\left(1 + \dfrac{T_{\alpha_U}}{T_U} + \dfrac{I_{UG} + I_{UN}}{N_U}\right)}\end{aligned} \tag{2}$$

The notations used in equation (2) are defined as follows:

- $(C/N)_{UC}$: carrier-to-noise ratio for uplink in clear sky (T_U only)
- DG_U: degradation factor for uplink
- α_U: rain attenuation in uplink ($0 < \alpha_U < 1$) (a random variable)
- I_{UN}: interference power from non-GSO systems in uplink (a random variable)
- I_{UG}: interference power received from other GSO systems in uplink
- T_{α_U}: noise temperature increase due to rain in uplink
- T_U: receive system noise temperature in uplink (≈ 617 K)
- N_U: thermal noise power in uplink receiver.

$N_U = k\, T_U\, B$, where k is the Boltzmann's constant and B is the receiver noise bandwidth. Rain attenuation α_U directly reduces the received carrier power. The denominator of equation (2) represents effective noise, relative to T_U, with the inclusion of rain noise temperature and interference contributions from GSO and non-GSO systems. Like the carrier, interference contributions are attenuated with the factor α_U by rain.

Likewise, the downlink C/N equation is expressed as:

$$\begin{aligned}(C/N)_D &= (C/N)_{DC}\, DG_D \\ &= \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)}\end{aligned} \tag{3}$$

where:

$N_D = k\, T_D\, B$

- $(C/N)_{DC}$: carrier-to-noise ratio for downlink in clear sky (T_D only)
- DG_D: degradation factor for downlink
- α_D: rain attenuation in downlink ($0 < \alpha_D < 1$) (a random variable)
- I_{DN}: interference power from non-GSO systems in downlink (a random variable)
- I_{DG}: interference power received from GSO systems in downlink
- T_{α_D}: noise temperature increase due to rain in downlink
- T_D: system noise temperature in downlink (≈ 125 K)
- N_D: thermal noise power in downlink receiver.

The total C/N is therefore:

$$C/N = \frac{(C/N)_{DC}\, DG_D}{1 + \dfrac{(C/N)_{DC}\, DG_D}{(C/N)_{UC}\, DG_U}}$$

$$= \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)} \left[1 + \frac{(C/N)_{DC}}{(C/N)_{UC}} \frac{\dfrac{1}{\alpha_U}\left(1 + \dfrac{T_{\alpha_U}}{T_U} + \dfrac{I_{UG} + I_{UN}}{N_U}\right)}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)}\right]^{-1} \quad (4)$$

Equation (4) includes DG, a degradation factor to $(C/N)_{DC}$, the downlink C/N in clear sky. Notice that $(C/N)_{DC}$ is also the performance factor all degradations are evaluated to in Methodology A of Recommendation ITU-R S.1323. $DG_U \leq 1$, $DG_D \leq 1$, $DG \leq 1$, and a positive degradation factor (dB) is defined as $DG_{dB} = -10 \log_{10}(DG) \leq 0$. The degradation factor in equation (4) uses a pdf integration method to calculate the unavailability. The downlink degradation factor DG_D appears twice in the equation but only need be calculated once.

As in Recommendation ITU-R S.1323, rain and non-GSO interference are assumed to occur independently. However, the impact of interference on degradation is dependent on rain. Specifically, rain increases system noise temperature and attenuates interference as well as carrier. Therefore, non-GSO interference has a lesser degradation effect in rain than in the clear sky. This is a major difference between the methodology proposed here and Methodology A in Recommendation ITU-R S.1323.

Equation (4) may be simplified with appropriate approximations. The first approximation ignores everything other than clear-sky thermal noise (N_U) in the uplink. With $\alpha_U = 1$, $T_{\alpha_U} = 0$, and $I_{UN} = I_{UG} = 0$ in equation (2), DG_U is found to be 1 (no degradation) and thus:

$$(C/N)_U = (C/N)_{UC}\, DG_U = (C/N)_{UC} \quad (5)$$

Equation (4) is now reduced to:

$$C/N = \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)} \left[1 + \frac{(C/N)_{DC}}{(C/N)_{UC}} \frac{1}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)}\right]^{-1} \quad (6)$$

The next approximation goes one step beyond by ignoring the entire uplink in its degradation on the total link. With the reciprocal portion of equation (6) set to 1, the expression for total C/N is simplified to:

$$C/N = \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D} + \dfrac{I_{DG} + I_{DN}}{N_D}\right)} \quad (7)$$

The increase in system noise temperature in equation (7) may be evaluated by:

$$T_{\alpha_D} = T_{D_m}\left(1 - 10^{\frac{-\alpha_{D_{dB}}}{10}}\right) \quad (8)$$

where T_{D_m} is the rain temperature (≈ 290 K) and $\alpha_{dB} = -10 \log_{10}(\alpha) \geq 0$ is rain attenuation (dB). Equation (8) also applies to equations (4) and (6).

The quasi-complete model of equation (7) is valid if uplink $(C/N)_U$ is much higher than downlink $(C/N)_D$, which is true in typical situations, particularly when power control is adopted in uplink to offset rain attenuation. However, in arriving at equation (7) one should bear in mind the fact that α_U is smaller than α_D due to the higher uplink frequency. The smaller α_U tends to make the reciprocal portion of equation (4) less negligible.

The results reported in this Recommendation are based on equation (7).

As mentioned above, the Monte Carlo method allows rain attenuation and non-GSO system interference level to vary with time according to their statistics. All other parameters are assumed constant. The Monte Carlo experiments model the time-varying parameters as random variables to evaluate C/N degradation, such as with equation (7). To elaborate, the statistics of system degradation due to rain and non-GSO interference are produced with random variables according to their cumulative density functions (CDFs). (In this version of the simulation algorithm, the CDF for rain is derived from Recommendation ITU-R P.618 with the ITU rain model or the Crane rain model, and the CDF of non-GSO is from its epfd mask.) To evaluate equation (4), one random variable each is required for uplink rain, uplink non-GSO interference (apfd), downlink rain, and downlink non-GSO interference (epfd). To evaluate equation (6) or (7), two random variables representing downlink rain and non-GSO interference suffice.

The complement of the CDF (CDF_C) for a given rain attenuation α_{dB} is related to $A_{0.01}$, the minimum rain attenuation in dB for 0.01% of the time. From Recommendation ITU-R P.618, it is found to be:

$$CDF_C(\alpha_{dB}) = 10^{11.628\left[-0.546+\sqrt{0.298+0.172\log_{10}\left(0.12\frac{A_{0.01}}{\alpha_{dB}}\right)}\right]}/100 \tag{9}$$

which is valid for all CDF_C not exceeding 1%.

For each sample of the random variables independently generated for rain and non-GSO interference, the Monte Carlo methodology calculates their combined effect according to the equation (such as equation (7)) and arrives at a system degradation value. This process is repeated for a large number of samples. A histogram is built from these degradation values to form a degradation distribution. The distribution is converted to a system availability curve based on the rain degradation characteristics of equation (9). The simulation process is repeated for the cases with and without non-GSO interference. Availability reduction caused by the non-GSO interference is calculated by subtracting the unavailability figure without the non-GSO interference from that with the non-GSO interference. The procedure is summarized below.

2.2 Procedure for Monte Carlo simulation

Step 1: Build a rain impact table with entries in CDF_C vs. rain degradation. Also build a non-GSO interference impact table with entries in CDF_C vs. interference degradation.

Step 2: Sample a degradation value from the rain table. Also sample a degradation value from the non-GSO table.

Step 3: Compute the total degradation using equations (7) and (8).

Step 4: Repeat Step 2 for all rain and non-GSO samples.

Step 5: Build a histogram of total degradation based on results from Step 3.

Step 6: Repeat Steps 1 through 5 for the case with and without non-GSO interference. Plot the histograms with and without non-GSO interference.

Step 7: Look up the CDF_C values at the clear-sky margin for the cases with and without non-GSO interference.

Step 8: Compute the increase in unavailability due to non-GSO interference.

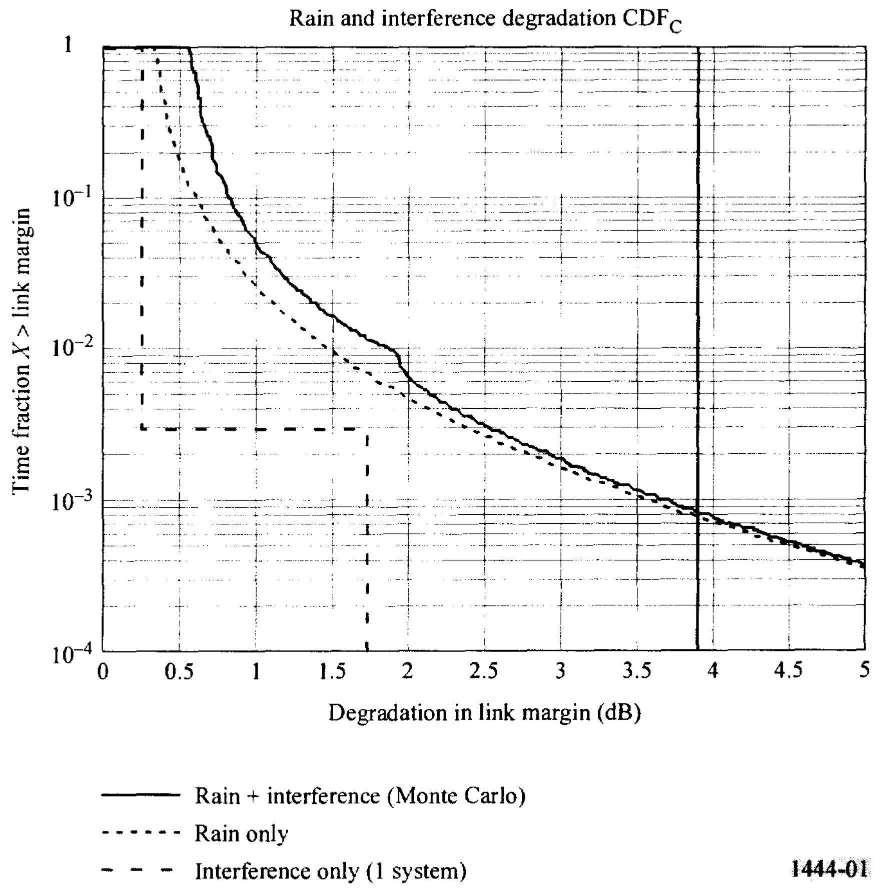
Other parameters needed to calculate C/N degradation in equation (7) can be derived from the spreadsheet of Annex 1 for a given link scenario. T_D of equation (7) is the same as row 27 or 28 of the spreadsheet. T_{D_m} is 290 K, which is used to compute row 38. I_{DG}/N_D is calculated by combining C/I_{DG} and C/N_D. Notice that C/I_{DG} is obtained by combining row 10 and row 11, and C/N_D is obtained by combining row 13, row 15 and C/I_{DG}.

2.3 Discussion of a sample simulation result

Figure 1 shows an example unavailability plot from a Monte Carlo simulation with equation (7). This example calculation is performed with the non-GSO interference faded by rain; calculations performed with non-GSO interference not faded by rain would proceed in the same manner. The BSS system evaluated is a typical system servicing the continental United States of America. The receive antenna simulated is located in Seattle, Washington, which is in ITU-R Rain Zone D. The interference mask is the WRC-97 provisional limits for a 45 cm receive antenna.

FIGURE 1

Example unavailability plot



1444-01

The horizontal axis of the plot represents the amount of degradation relative to thermal noise N_D (dB) and the vertical axis represents time fractions. The staircase represents the curve which is the CDF_C of the provisional epfd limits (or the CDF for the absence of the epfd). The provisional limits are shown to produce 0.25 dB of degradation 99.7% of the time (from $I_{DN}/N_D = -12.3$ dB) and 1.67 dB of degradation the remaining 0.3% of the time (from $I_{DN}/N_D = -3.3$ dB).

The two other curves in the plot bear similar shapes. Each curve represents a CDF_C of degradation, i.e. the unavailability as a function of degradation. The time fraction above the curve is the CDF of degradation, or availability as a function of degradation. Although the rain degradation equation (9) is valid only for time fractions not exceeding 1%, it was used to plot all time fractions for convenience. The artificial extension to 100% time fraction does not cause problems to actual results since most unavailabilities of interest are below 1%. The lower curve is without non-GSO interference and therefore has smaller unavailability values. The upper curve is for the case when non-GSO interference is added.

The long-term portion of the non-GSO interference causes an unavailability curve to shift to the right by 0.25 dB at the 100% time fraction. The shift gets smaller as the degradation gets larger. This is because heavier rain attenuation reduces the impact of interference, as discussed above. The shift is the amount of additional carrier power that would be required to offset the long-term interference effect if so required.

Both unavailability curves include a constant GSO interference. The GSO interference causes the CDF_C curves to start at approximately 0.28 dB at the 100% time fraction. The 0.28 dB degradation value comes from an I_{DG}/N_D of −11.8 dB.

The blip on the upper curve is caused by short-term interference. The time fraction at the blip is approximately the sum of the time fractions for rain and non-GSO interference at the degradation level. (Since rain and interference are both of low probability at this degradation level, the probability of having either of them is the sum of the two probabilities.) The blip has been right-shifted from the short-term degradation value by 0.28 dB due to constant GSO interference as mentioned above. As one moves away from the blip to the right on the curve with the presence of non-GSO interference, the unavailability time fraction drops rapidly toward the non-GSO free curve. Therefore, providing a small margin beyond the blip will ensure a relatively benign increase in system unavailability caused by non-GSO interference. These factors should be considered when designing the epfd masks.

The vertical bar at the 3.9 dB degradation represents the system clear-sky margin (CSM) before including the effects of adjacent GSO BSS interference, adjacent GSO FSS interference, and uplink effects. System unavailabilities are read off the two curves at this point. The difference between the two values at the CSM is the unavailability increase due to non-GSO interference. The unavailability increase ratio is the unavailability increase divided by the unavailability without non-GSO interference. The example plot of Fig. 1 shows an increase in the ratio of approximately 8.7%. Notice that the smallest and largest tic intervals on the vertical logarithmic scale represent 10% and 100% increases of unavailability, respectively.

APPENDIX 1

TO ANNEX 3

In this Appendix, the Monte Carlo degradation equations are developed for the case of the non-GSO interference faded by rain. The noise, N, in a carrier-to-noise ratio, C/N, refers to the sums of all unwanted powers for a particular situation, such as thermal noise, noise temperature increase from rain, GSO interference, and/or non-GSO interference.

The total C/N is affected by uplink and downlink as:

$$C/N = \frac{(C/N)_U \cdot (C/N)_D}{(C/N)_U + (C/N)_D} = \frac{(C/N)_D}{1 + \dfrac{(C/N)_D}{(C/N)_U}} \tag{10}$$

in which $(C/N)_U$ and $(C/N)_D$ are the uplink C/N and the downlink C/N, respectively. In turn, $(C/N)_U$ is expressed as:

$$\begin{aligned}(C/N)_U &= (C/N)_{UC}\, DG_U \\ &= \frac{(C/N)_{UC}\, \alpha_U}{1 + \dfrac{T_{\alpha_U}}{T_U} + \alpha_U\left(\dfrac{I_{UG} + I_{UN}}{N_U}\right)} \\ &= \frac{(C/N)_{UC}}{\dfrac{1}{\alpha_U}\left(1 + \dfrac{T_{\alpha_U}}{T_U}\right) + \left(\dfrac{I_{UG} + I_{UN}}{N_U}\right)}\end{aligned} \tag{11}$$

The notations used in equation (11) are defined as follows:

$(C/N)_{UC}$: carrier-to-noise ratio for uplink in clear sky (T_U only)

DG_U: degradation factor for uplink

α_U: rain attenuation in uplink ($0 < \alpha_U < 1$) (a random variable)

I_{UN}: interference power from non-GSO systems in uplink (a random variable)

I_{UG}: interference power received from other GSO systems in uplink

T_{α_U}: noise temperature increase due to rain in uplink

T_U: receive system noise temperature in uplink ($\approx$ 617 K)

N_U: thermal noise power in uplink receiver.

$N_U = k\ T_U\ B$, where k is the Boltzmann's constant and B is the receiver noise bandwidth. Rain attenuation α_U directly reduces the received carrier power. The denominator of equation (11) represents effective noise, relative to T_U, with the inclusion of rain noise temperature and interference contributions from GSO and non-GSO systems. Like the carrier, interference contributions are attenuated with the factor α_U by rain.

Likewise, the downlink C/N equation is expressed as:

$$(C/N)_D = (C/N)_{DC}\ DG_D = \frac{(C/N)_{DC}}{\frac{1}{\alpha_D}\left(1 + \frac{T_{\alpha_D}}{T_D}\right) + \left(\frac{I_{DG} + I_{DN}}{N_D}\right)} \tag{12}$$

where:

$N_D = k\ T_D\ B$.

$(C/N)_{DC}$: carrier-to-noise ratio for downlink in clear sky (T_D only)

DG_D: degradation factor for downlink

α_D: rain attenuation in downlink ($0 < \alpha_D < 1$) (a random variable)

I_{DN}: interference power from non-GSO systems in downlink (a random variable)

I_{DG}: interference power received from GSO systems in downlink

T_{α_D}: noise temperature increase due to rain in downlink

T_D: system noise temperature in downlink ($\approx$ 125 K)

N_D: thermal noise power in downlink receiver.

The total C/N is therefore:

$$C/N = \frac{(C/N)_{DC}\ DG_D}{1 + \frac{(C/N)_{DC}\ DG_D}{(C/N)_{UC}\ DG_U}}$$
$$= \frac{(C/N)_{DC}}{\frac{1}{\alpha_D}\left(1 + \frac{T_{\alpha_D}}{T_D}\right) + \left(\frac{I_{DG} + I_{DN}}{N_D}\right)} \left[1 + \frac{(C/N)_{DC}}{(C/N)_{UC}} \frac{\frac{1}{\alpha_U}\left(1 + \frac{T_{\alpha_U}}{T_U}\right) + \left(\frac{I_{UG} + I_{UN}}{N_U}\right)}{\frac{1}{\alpha_D}\left(1 + \frac{T_{\alpha_D}}{T_D}\right) + \left(\frac{I_{DG} + I_{DN}}{N_D}\right)}\right]^{-1} \tag{13}$$

Equation (13) includes DG, a degradation factor to $(C/N)_{DC}$, the downlink C/N in clear sky. Notice that $(C/N)_{DC}$ is also the performance factor all degradations are evaluated to in Methodology A of Recommendation ITU-R S.1323. $DG_U \leq 1$, $DG_D \leq 1$, $DG \leq 1$, and a positive degradation factor (dB) is defined as $DG_{dB} = -10\ \log_{10}(DG) \geq 0$. The downlink degradation factor DG_D appears twice in the equation but only need be calculated once.

As in Recommendation ITU-R S.1323, rain and non-GSO interference are assumed to occur independently. However, the impact of interference on degradation is dependent on rain. Specifically, rain increases system noise temperature and attenuates interference as well as carrier. Therefore, non-GSO interference has a lesser degradation effect in rain than in the clear sky. This is a major difference between the methodology proposed here and Methodology A in Recommendation ITU-R S.1323.

Equation (13) may be simplified with appropriate approximations. The first approximation ignores everything other than clear-sky thermal noise (N_U) in the uplink. With $\alpha_U = 1$, $T_{\alpha_U} = 0$, and $I_{UN} = I_{UG} = 0$ in equation (11), DG_U is found to be 1 (no degradation) and thus:

$$(C/N)_U = (C/N)_{UC}\, DG_U = (C/N)_{UC} \tag{14}$$

Equation (13) is now reduced to:

$$C/N = \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D}\right) + \left(\dfrac{I_{DG} + I_{DN}}{N_D}\right)} \left[1 + \frac{(C/N)_{DC}}{(C/N)_{UC}} \frac{1}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D}\right) + \left(\dfrac{I_{DG} + I_{DN}}{N_D}\right)}\right]^{-1} \tag{15}$$

The next approximation goes one step beyond by ignoring the entire uplink in its degradation on the total link. With the reciprocal portion of equation (15) set to 1, the expression for total C/N is simplified to:

$$C/N = \frac{(C/N)_{DC}}{\dfrac{1}{\alpha_D}\left(1 + \dfrac{T_{\alpha_D}}{T_D}\right) + \left(\dfrac{I_{DG} + I_{DN}}{N_D}\right)} \tag{16}$$

The increase in system noise temperature in equation (16) may be evaluated by:

$$T_{\alpha_D} = T_{D_m}\left(1 - 10^{\frac{-\alpha_{D_{dB}}}{10}}\right) \tag{17}$$

where T_{D_m} is the rain temperature ($\approx$ 290 K) and $\alpha_{dB} = -10 \log_{10}(\alpha) \geq 0$ is rain attenuation (dB). Equation (17) also applies to equations (13) and (15).

The quasi-complete model of equation (16) is valid if uplink $(C/N)_U$ is much higher than downlink $(C/N)_D$, which is true in typical situations, particularly when power control is adopted in uplink to offset rain attenuation. However, in arriving at equation (16) one should bear in mind the fact that α_U is smaller than α_D due to the higher uplink frequency. The smaller α_U tends to make the reciprocal portion of equation (13) less negligible. The results reported in this Appendix are based on equation (16).

ANNEX 4

Methodology to assess the impact of the 100% of the time epfd$_{\text{down}}$ and epfd$_{\text{up}}$ values according to *recommends* 1.2

This Annex contains an approach to assess the impact of the 100% of the time epfd$_{\text{down}}$ and epfd$_{\text{up}}$ values according to *recommends* 1.2. This is performed as follows:

Step 1: Calculate the $(C/I)_{epfdup}$ value resulting from the epfd$_{\text{up}}$, when applicable:

$$(C/I)_{epfdup} = e.i.r.p._{up} - L_{pup} - L_{gup} - L_{plup} - (epfd_{up} - G_{up}(1\ \text{m}^2)) - 10 \log(N_{eff}) - B + B_{ref}$$

Step 2: Calculate the $(C/I)_{epfddown}$ value resulting from the $epfd_{down}$, when applicable:

$$(C/I)_{epfddown} = e.i.r.p._{down} - L_{pdown} - L_{gdown} - L_{pldown} - (epfd_{down} - G_{down}(1\ \text{m}^2)) - 10\log(N_{eff}) - B + B_{ref}$$

Step 3: Calculate the clear sky $C/(N+I)$ including the effect of the (C/I) values computed in Step 1 (if applicable) and in Step 2:

$$C/(N+I)_{cs+epfds} = -10\log(10\text{^}(-0.1\ C/(N+I)_{cs}) + 10\text{^}(-0.1\ (C/I)_{epfdup}) + 10\text{^}(-0.1\ (C/I)_{epfddown}))$$

Step 4: Calculate the margin M between $C/(N+I)_{cs+epfds}$ and the threshold value referred in *recommends* 1.2 $(C/N+I))_{ffthr}$:

$$M = -10\log(10\text{^}(-0.1\ C/(N+I)_{ffthr} - 10\text{^}(-0.1\ C/(N+I)_{cs+epfds})$$

Step 5: If the Margin M is negative then a loss of video picture continuity is expected to occur.

Where:

$(C/I)_{epfdup}$:	the carrier-to-interference value resulting from the $epfd_{up}$
$epfd_{up}$:	the assumed non-GSO uplink 100% of the time epfd value (dB(W/(m$^2 \cdot B_{ref}$)))
$e.i.r.p._{up}$:	the uplink e.i.r.p. (dBW)
L_{pup}:	the path loss in the uplink (dB)
L_{gup}:	the gaseous attenuation in the uplink (dB)
L_{plup}:	the antenna pointing loss in the uplink (dB)
G_{up} (1 m^2):	the gain per square metre in the uplink (dB)
$(C/I)_{epfddown}$:	the carrier-to-interference value resulting from the $epfd_{down}$
$epfd_{down}$:	the assumed non-GSO downlink 100% of the time epfd value (dB(W/(m$^2 \cdot B_{ref}$)))
$e.i.r.p._{down}$:	the downlink e.i.r.p. (dBW)
L_{pdown}:	the path loss in the downlink (dB)
L_{gdown}:	the gaseous attenuation in the downlink (dB)
L_{pldown}:	the antennae pointing loss in the downlink (dB)
G_{down}(1 m^2):	the gain per square metre in the downlink (dB)
$C/(N+I)_{cs}$:	the clear sky $C/(N+I)$ of the link, without the effect of non-GSO interference (dB)
$C/(N+I)_{ffthr}$:	the threshold value corresponding to loss of video picture continuity (dB)
$C/(N+I)_{cs+epfds}$:	the combined effect of clear sky $C/(N+I)$ and the non-GSO
N_{eff}:	the effective number of non-GSO systems
B_{ref}:	the reference bandwidth in which the epfd is defined (dB)
B:	the bandwidth of the GSO carrier (dB).

3.1.3 Sharing between non-GSO FSS and GSO BSS systems in the bands 11.7-12.5 GHz (Region 1), 11.7-12.2 GHz and 12.5-12.75 GHz (Region 3), 12.2-12.7 GHz (Region 2), 17.3-18.1 GHz (Regions 1 and 3) and 17.8-18.1 GHz (Region 2)

3.1.3.1 Protection of GSO BSS systems

Resolution **538 (WRC-97)** introduced provisional EPFD and APFD (which is re-defined as $EPFD_{up}$) limits for non-GSO FSS systems in certain bands intended to protect GSO BSS systems operating co-frequency, and requested ITU-R to conduct the appropriate technical, operational and regulatory studies to review the regulatory conditions relating to the coexistence of non-GSO FSS and GSO BSS systems.

ITU-R developed a draft new Recommendation ITU-R BO.[Doc. 11/138], referred to as BSS draft new Recommendation in the rest of § 3.1.3. This Recommendation addresses protection criteria, contains the BSS links to be protected, and descriptions of methodologies to be used in verifying protection of the BSS. The work was performed under the following principles:

a) that the equivalent power flux-density limits as defined in Article **S22** of the RR and applicable respectively to non-GSO FSS systems to be operated in the 12 GHz bands shared with BSS and in the 17 GHz frequency bands shared with BSS feeder links be derived and specified in such a way:

- that they satisfy the criteria in *recommends* 1.1 and 1.2 of the above draft new Recommendation when applied to a set of representative GSO BSS and associated feeder-link system characteristics, as provided in Annex 1 to this Recommendation;
- that the apportionment of the aggregate interference allowance specified in *recommends* 1.1 and 1.2 to derive single entry limits be based on the effective number of non-GSO FSS systems that are anticipated to share the same frequency bands;
- that these limits are specified by continuous curves of cumulative density function for a range of representative GSO receiving antenna sizes.

3.1.3.1.1 Characteristics of the GSO BSS

In performing the studies requested by Resolution **538 (WRC-97)**, it was clearly impracticable for ITU-R to gather and analyse data on all existing and planned GSO BSS networks using the frequency bands covered by Appendices **S30** and **S30A**. In Circular Letters CR/92 (14 April 1998) and CR/116 (15 February 1999), administrations were therefore invited to supply data on a set of representative GSO BSS links. A number of administrations responded to these letters, ITU-R has assembled those responses received prior to 22 March 1999 into a database of GSO BSS parameters.

This database includes the detailed characteristics of more than 300 BSS links. Bearing in mind that it includes sensitive BSS links with respect to interference from non-GSO FSS systems, it was considered as the appropriate basis to assess the adequacy of the current limits, as well as alternative candidate limits, to ensure protection of GSO BSS links so as not to cause undue constraints on any of the systems involved, and has been used for this purpose.

The complete set of submitted links is contained in Annex 1 of draft new Recommendation ITU-R BO.[Doc. 11/138]. This database of links includes both reference parameter links, operational links and links representing future technologies. They represent links employing both digital modulation techniques and FM analogue modulation techniques. The range of earth station sizes is from 30 cm to 450 cm.

One important BSS characteristic used to calculate $EPFD_{down}$ statistics is the BSS receive antenna pattern. To provide reference patterns for this purpose, ITU-R developed a draft new Recommendation ITU-R BO.[Doc. 11/137]. This Recommendation provides a unified set of reference antenna patterns for all regions. A set of three reference patterns are provided: one for

$D/\lambda > 100$, one for $25.5 < D/\lambda \leq 100$, and one for $11 \leq D/\lambda \leq 25.5$. These patterns should be used when determining $EPFD_{down}$ statistics.

3.1.3.1.2 Protection criteria

Recommendation ITU-R BO.[Doc. 11/137] outlines the protection criteria for BSS from non-GSO FSS interference. It is noted that the criteria to protect GSO BSS systems from interference caused by non-GSO FSS systems are similar to those adopted for the protection of GSO FSS systems.

3.1.3.1.3 Methodologies used to assess the adequacy of the limits to protect GSO BSS

As discussed in the previous sections, there are two criteria for the protection of GSO BSS from non-GSO FSS interference.

ITU-R developed two methodologies to determine whether the first criterion, a 10% increase of the BSS link unavailability, was met. These two methodologies are described in detail in Annexes 2 and 3 of draft new Recommendation ITU-R BO.[Doc. 11/138]. *Recommends* 3 of BSS draft new Recommendation establishes that both of these methodologies could be used in assessing the impact on the GSO BSS from non-GSO FSS systems.

ITU-R also developed a methodology for assessing whether the second criterion, loss of video picture continuity, was met. This methodology is described in detail in Annex 4 of draft new Recommendation ITU-R BO.[Doc. 11/138].

In addition, it was agreed to use the method of § 3.1.2.1.3 b) to go from aggregate $EPFD_{down}$ mask to single entry $EPFD_{down}$ mask or vice versa. Since the BSS earth station antenna sizes are less than 10 m, it was decided to restrict this methodology to the power addition zone and the time addition zone.

Consistent with the approach of § 3.1.1.1 d), a value of 3.5 for "$N_{effective}$" was adopted in order to relate the single entry masks to the aggregate masks. It is noted that "$N_{effective}$" is used for computation purposes only and is not a representation of the actual number of non-GSO FSS systems that can share a given frequency band.

3.1.3.1.4 Results of studies relating to the review/revision of the provisional power limits appearing in Section II of Article S22 for the protection of GSO BSS systems subject to Appendix S30 plans and associated feeder links

a) $EPFD_{up}$ and $EPFD_{is}$ limits

The concepts of $EPFD_{up}$ and $EPFD_{is}$ limits were agreed. The first set of limits is to protect the GSO BSS feeder links receive space stations from interference caused by

non-GSO FSS transmit earth stations using an Earth-to-space allocation. The second set is to protect the GSO BSS feeder links receive space stations from interference caused by non-GSO FSS space stations using a space-to-Earth allocation.
The agreed single entry $EPFD_{up}$ limit is -160 dB(W/(m^2.40 kHz)). This $EPFD_{up}$ limit applies to the bands 17.3-18.1 GHz (Regions 1 and 3) and 17.8-18.1 GHz (Region 2). It is proposed that, the above-mentioned limit be also applicable to the frequency band 17.3-17.8 GHz (Region 2), in order to protect BSS feeder links in Region 2 from non-GSO FSS uplinks in Regions 1 and 3. With regard to the 17.3-17.8 GHz allocation to non-GSO FSS (uplink) in Region 2 see 3.2.2.
The agreed single entry $EPFD_{is}$ limit is -160 dB(W/(m^2.40 kHz)). This $EPFD_{is}$ limit applies to the bands 17.8-18.1 GHz.

b) $EPFD_{down}$

It was agreed that $EPFD_{down}$ masks specified by continuous curves of cumulative density function, as called by *recommends* 2.3 of the draft new Recommendation ITU-R BO.[Doc. 11/138], would be used rather than masks specified by discrete EPFD points as used in the provisional limits. Such continuous masks, specifying the maximum allowed level of $EPFD_{down}$ as a function of the percentage of time, would provide a more realistic fit to the interference caused by non-GSO FSS systems into GSO BSS systems.
The procedure described in § 3.1.3.1.3 above has been applied on the GSO BSS link included in the database reported in § 3.1.3.1.1 above for the 12 GHz band, in order to assess the compliance of candidate $EPFD_{down}$ limits with the protection criteria considered under § 3.1.3.1.2 above. The limits considered above for $EPFD_{up}$ and/or $EPFD_{is}$, as applicable, were also included in the calculations (aggregate value of -153 dB(W/(m^2.40 kHz)), which took into account the impact of non-GSO FSS interference on the overall GSO BSS links (feeder link + downlink).
Tables in Annexes 1 and 2 provide the $EPFD_{down}$ masks in terms of the allowable single entry and aggregate EPFD levels compatible with an effective number of 3.5 non-GSO FSS interfering systems into the various antenna sizes that may be considered for the receive earth station antenna.
These masks were agreed for all antenna diameters, i.e. 30 cm, 45 cm, 60 cm, 90 cm, 120 cm, 180 cm, 240 cm and 300 cm. This agreement reflects the compromise reached between the parties by not imposing unacceptable constraints on any of them. This agreement is based on the following:

- Validation $EPFD_{down}$ masks for the above BSS earth stations antennas diameter.
- Latitude dependent validation 100% of the time $EPFD_{down}$ limits for 180 cm, 240 cm and 300 cm BSS earth stations antennas.
- Operational 100% of the time single entry $EPFD_{down}$ limits for 240 cm BSS antenna diameters in a certain northern high latitude area of Region 2.

The limit in the third bullet is required because the power of BSS transmissions that can be radiated toward certain northern high latitude area of Region 2 is limited by the existing pfd limits section 5c) of Annex 1 to Appendix **S30**. This leads to the use of larger BSS earth station antennas in this geographical area and more sensitive links. But the protection of a limited area should not impose worldwide constraints on non-GSO FSS. This limit may be implemented during a transition period if the pfd limits in section 5c) of Annex 1 to Appendix **S30** are relaxed, taking into account the lifetime of operational

BSS spacecraft and those to be launched in a short term. Information on operational limit is provided in sections 3.1.2.4.7 and 3.1.6.2.
To assist administrations, further study is required within ITU-R to develop a methodology (either in a new Recommendation or a modification to an existing Recommendation) to determine the actual EPFD level radiated by the non-GSO FSS systems into a 240 cm GSO BSS antenna. It was agreed that a Resolution by WRC-2000 to undertake these studies as a matter of urgency would be appropriate.

3.1.3.2 Interference to non-GSO FSS systems from BSS systems

The use by non-GSO FSS systems of the frequency bands subject to Appendices **S30** and **S30A** Plans at 12 and 17 GHz was addressed by WRC-97 (Resolution **538 (WRC-97)**). It should be noted that *considering c)* of Resolution **538 (WRC-97)** states that "non-GSO systems should not be entered into these Plans and therefore should not apply the procedures associated with the Plans and should not be protected by these procedures".
A study presented to WRC-97 (Document CMR-97/62) advised that the interference from Appendices **S30** and **S30A** Plans into non-GSO FSS systems sharing the same bands would be acceptable, assuming that the e.i.r.p. levels of the assignments in the Plan do not exceed the levels of the 1977 and 1983 Plans.
On this basis, the ITU-R, noting that the plan modification process would in practice limit the possibility of exceeding these levels, concluded that there would be no need to introduce specific provisions to protect non-GSO FSS systems from modifications to Appendices **S30** and **S30A** Plans.
Further study on this issue may be required in the future if higher power levels appeared to be necessary in the BSS and BSS feeder links in Appendices **S30** and **S30A** Plans.
Concerning the interference that may be caused into non-GSO FSS uplinks by GSO BSS feeder links in the 17.8-18.1 GHz band in Region 2 and, should WRC-2000 decide an allocation to non-GSO FSS (Earth-to-space) in this band, in the 18.1-18.4 GHz band in all three Regions, it was concluded that off-axis e.i.r.p. limits similar to those considered for the 13.75-14.5 GHz might be appropriate. Further study is required however, to determine the appropriate level for these limits.

3.1.3.3 Regulatory and procedural considerations

There is a need to ensure that the aggregate EPFD produced by all co-frequency non-GSO FSS systems does not exceed the maximum interference levels, as determined by the agreed to aggregate EPFD masks, that are necessary to protect these GSO BSS systems.
Some of the considerations in § 3.1.2.4 (including 3.1.2.4.9) apply also in this case.